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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
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EXAMINER	
CANTELMO,G	
ART UNIT	PAPER NUMBER
1753	11

DATE MAILED: 09/26/01

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary	Application No.	Applicant(s)	
	09/476,669	LAU, GORLEY L.	
	Examiner	Art Unit	
	Gregg Cantelmo	1753	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *16 July 2001* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-18 and 21-30* is/are pending in the application.

4a) Of the above claim(s) *24-30* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-18 and 21-23* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☒ The proposed drawing correction filed on *16 July 2001* is: a)☒ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Response to Amendment

1. In response to the amendment received July 16, 2001:

   a. Claims 19 and 20 have been canceled;

   b. The drawing objections have been withdrawn;

   c. The 112 rejections have been withdrawn;

   d. The prior art rejections of the previous office action have been withdrawn.

Election/Restrictions

1. Newly submitted claims 24-29 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons: these new claims are drawn to application of a backside gas to the topography of the substrate which is not a feature originally claimed in those claims which received action on the merits.

Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claims 24-29 are withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

2. Newly submitted claim 30 directed to an invention that is independent or distinct from the invention originally claimed for the following reasons: claim 30 recites an

etching step to etch the cavity such not being positively claimed in the originally filed claims which received an action on the merits

Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claim 30 is withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

Information Disclosure Statement

3. The references filed in conjunction with the amendment fails to comply with the provisions of 37 CFR 1.97, 1.98 and MPEP § 609 because these references have not been cited by applicant on the appropriate form PTO 1449 nor the appropriate fee paid for consideration. These references have been placed in the application file, but the information referred to therein has not been considered as to the merits unless cited by the Examiner on a form PTO 892. If applicant wishes to have these references considered on the record, Applicant must recite these references on a form PTO 1449 and pay the requisite fees.

Drawings

4. The proposed drawing correction and/or the proposed substitute sheets of drawings, filed on July 16, 2001 have been approved by the Examiner for examination purposes.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claims 1-11 and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. patent No. 6,217,721 (Xu) in view of U.S. patent No. 6,176,983 (Bothra) and U.S. patent No. 5,882,488 (Leiphart)

Xu is drawn to a method of filling contact holes. The method generally comprises forming a liner layer (i.e. wetting layer) and a subsequent bulk metal layer atop the liner layer (see abstract). The liner comprises titanium which is generally known as a wetting material (col. 6, ll. 41-45).

The liner layer is deposited by HPD PVD and the aluminum layer by standard PVD of a multi-temperature aluminum deposition that occurs in either one or two chambers (col. 8, ll. 8-15 and 24-29).

More specifically the HDP process is as follows: cathode and coil sources 180, 188 are turned on to create a high-density argon plasma, and the anode power source is turned on to DC self-bias the wafer 176. Argon sputters the target 172 and the resulting titanium particles in traversing the high-density plasma are at least partially ionized (hence creating IMP). The self-bias on the wafer causes the ionized Ti particles to strike the wafer in directions approximately normal to the wafer principal surface, thus

providing high coverage on the bottom of the contact hole and reduced coverage on the sidewalls (col. 18, ll. 1-13 as applied to claim 1).

Figs. 16 and 17 show a multilevel interconnect which employs multiple liner/metal layers. Atop each lower level liner (or wetting layer for lining metal-1, is a dielectric layer 314 for the next contact fill. Thus there is a dielectric layer form above the liner to form subsequent metal lines (as applied to claim 2). Fig. 8 shows bulk metal layer 156 which fills the cavity (as applied to claim 3). As indicated above the liner comprises titanium (as applied to claim 4). Fig. 17 shows forming the wetting layer 150 on sidewalls of the cavity in dielectric layer 314 and upon an upper surface of layer 310 of the lower portion of a microelectronic topography (as applied to claim 5). As discussed above the directionality of the sputtered titanium atoms directed towards the substrate is substantially perpendicular to the dielectric layer (as applied to claim 6).

The system shown in Fig. 10 as well as the disclosure of the process discussed above teaches of using a target having DC power applied to it to sputter titanium from a titanium target, using an RF induction coil 188 to ionize a portion of the metal sputtered from the target and a substrate bias 182 to direct the atoms normal to the dielectric layer (as applied to claim 7). The cavity comprises a via 320 in the dielectric layer 314 which extends to a conductive region at the bottom of the via (Fig. 16 as applied to claim 8). With inter-level vias, it is preferred to facet the upper corners of the via hole 320 by an etching and pre-cleaning process, as described by Ong, ibid. Such faceting is not used with contacts, because the energetic plasma particles are likely to damage

the exposed silicon (col. 25, ll. 62-67 as applied to claims 9 and 10). The bulk layer comprises aluminum and the wetting layer comprises titanium (as applied to claim 11).

The differences between the instant claims and Xu is that Xu does not teach of imparting a bias to resputter material from the bottom of the contact hole onto the sidewalls (claim 1) or of applying the bias during deposition (claim 21).

With respect to claim 1:

Bothra teaches of directing process gas ions or sputtering ions to the semiconductor workpiece to strike and distribute at least a portion or some of the process layer (Ti wetting layer) from the first area 49 (bottom) to second areas 51 (corners and lower sidewalls) and areas 48a (sidewalls). This provides a dense and effective barrier layer (col. 7, ll. 4-14).

In order to control the degree of directional attraction of ions to a substrate one of ordinary skill in the art would have readily considered the obvious modification of application of a substrate bias potential relative to the plasma to cause resputtering. Increasing the substrate bias will increase the attraction of ions and thus increase the rate of resputtering as taught by Leiphart.

More particularly:

A wafer bias is applied during the second bias step, such that a portion of the deposited material on the contact bottom is resputtered onto contact sidewalls. In the preferred case, titanium is the deposited material. A subsequent anneal step in a nitrogen-containing ambient forms a passivating titanium nitride film on the sidewalls of

the contact. This passivating film protects the underlying substrate from degradation when metal interconnect material is subsequently deposited in the contact hole. By resputtering a portion of the deposited titanium onto the sidewalls of the contact hole, chemical vapor deposition of titanium nitride is not required to form a titanium nitride film on the contact sidewalls (col. 4, ll. 17-29). It is preferable not to use CVD to deposit titanium nitride films on sidewalls of contacts because CVD-deposited films often contain unwanted impurities, introduced during the CVD process.

The motivation for biasing the substrate is to attract ionized particles to the wafer to cause resputtering of deposited material from the bottom of the contact hole onto the sidewall of the contact hole thereby improving sidewall coverage and overall step coverage of the contact hole. This further eliminates the need for a CVD deposition of titanium nitride to form titanium nitride on the contact sidewalls.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Xu by biasing the substrate as taught by Bothra and Leiphart since it would have caused resputtering of deposited material from the bottom of the contact hole onto the sidewall of the contact hole thereby improved sidewall coverage and overall step coverage of the contact hole.

With respect to claim 21:

Leiphart teaches of applying a substrate bias during deposition. While application of a substrate bias slows the net accumulation of the material at the contact

hole, it is needed to prevent material overhang from obstructing the paths of sputtered atoms (col. 8, ll. 39-43 as applied to claim 21).

The motivation for applying the bias to the substrate during deposition is minimize overhang thereby preventing obstruction of the paths of sputtered atoms into the contact hole.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Xu by applying the substrate bias during deposition of the liner layer as taught by Leiphart since it would have minimized overhang and prevented obstruction of the paths of the sputtered atoms into the contact hole.

7. Claims 12-14, 16-18 and 22-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. patent No. 5,270,255 (Wong) in view of U.S. patent No. 5,962,923 (Xu '923)

Wong discloses depositing a titanium comprising layer (i.e. titanium comprising wetting layer) within a contact hole. Thereafter a bulk metal is deposited in three steps: a first cold layer, a second hot layer and a third cold layer (col. 2, ll. 20-30 and col. 3, line 30 through col. 4 line 7 as applied to claim 12). The temperature of the first metal layer (150 ° or less) is such that promotes adhesion of the subsequent hot metal layer while not causing significant reflow (col. 3, ll. 34-39 as applied to claim 13). The temperature of the second hot metal step is to cause reflow of the second portion (col. 3, ll. 50-55 as applied to claim 14). The process teaches of forming the first layer atop

the titanium comprising layer (col. 3, ll. 30-34) and the second bulk metal layer is deposited atop the first metal layer (col. 3, ll. 35-38 and 50-52 as applied to claim 16). The process teaches of forming the first layer atop the titanium-comprising layer (col. 3, ll. 30-34) and the second bulk metal layer is deposited to fill the contact opening (col. 3, ll. 54-56 as applied to claim 17). The sputter depositing is performed after forming the wetting layer (as applied to claim 18). The second temperature for the hot reflow is higher than the first temperature for the cold sputter step (as applied to claim 22).

The differences between the instant claims and Wong is that Wong does not disclose IMP depositing the titanium comprising layer (claim 12) and of the third layer being approximately 50% of the bulk layer (claim 23).

With respect to claim 12:

IMP sputtering is a technological process which was known to one of ordinary skill in the art. IMP titanium comprising layers in contact holes was taught by

Ion Metal Plasma (IMP) sputter deposition is a method of PVD which provides uniform barrier layer bottom and sidewall coverage in small contacts. IMP sputter deposition of titanium comprising barrier layers is disclosed in Xu '923.

Although ionized deposition is a known way of filling high aspect ratio holes, the technique is significantly more expensive than traditional sputtering techniques because the deposition rate is slower, the power requirements are greater and the equipment is more expensive than traditional sputtering equipment. Notwithstanding these limitations, it is believed by those skilled in the art that the filling of very high aspect ratio

holes, i.e., those above approximately 2:1, may only be accomplished using ionized deposition material, and that other techniques, such as coherent deposition followed by traditional sputter deposition and reflow cannot meet the needs of device fabricators as line widths continue to shrink (Xu '923 col. 3, ll. 25-38).

The bottom coverage obtained using ionized deposition of sputtered particles has been demonstrated to be more than ten times greater than that achieved using standard sputtering techniques

Xu '923 found that the lining provided by the deposition of ionized sputter material as described herein provides the greatest advantage, i.e., the greatest improvement in hole filling capability, where the conductor is provided by conventional sputtering. In particular, the lining provided by ionized sputtering allows filling of the apertures with conventional sputtering (col. 14, ll. 53-59).

The motivation for using IMP sputtering is that it improves the directionality of sputtered atoms from the target to the contact holes thereby enhancing deposition of material into the contact hole. Furthermore, as the aspect ratio of the contact holes increase, use of standard PVD deposition of titanium comprising layers as barrier or wetting layers does not achieve good conformal coatings in the contact holes. IMP overcomes this deficiency by controlling the directionality of the ionized sputtered atoms.

The motivation for using IMP sputter deposition for the titanium comprising wetting layer is to control the directionality of the ionized sputtered material and improve deposition of the wetting layer within the contact hole.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Wong by using IMP sputtering for the titanium comprising wetting layer at taught by Xu '923 since it would have controlled the directionality of the ionized sputtered material and improved the deposition of the wetting layer within the contact hole.

With respect to claim 23:

Wong teaches of a first deposition thickness range of 1000 to 1500 Angstroms (col. 3, ll. 31-32) a second deposition thickness of 2000 to 4000 Angstroms (col. 3, ll. 54-55) and a third deposition thickness of 2000 to 5000 Angstroms (col. 3, ll. 67-68). There is a broad range of thicknesses for each of these portions. One of ordinary skill would have found it obvious to select any range of thicknesses for each layer as desired. For example a first thickness of 1000 Angstroms, a second thickness of 2000 Angstroms and a third thickness of 3000 Angstroms are all within the acceptable ranges of Wong. Thus in selecting ranges, various percentage relationships would result inclusive of the third layer being approximately 50% of the whole bulk layer.

The examiner looked to the specification for the criticality of this limitation (see page 24, lines 15-25). The specification recites this relationship as an embodiment and fails to teach of any novelty, criticality, or unexpected results associated with this limitation.

The thickness ranges of Wong include layer amounts which would suggest and obviate the third layer having about 50% of the overall bulk layer thickness. Selection of

the thicknesses would have been a result effective variable that would have been within the skill of the ordinary worker in the art.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Wong by selecting the third layer to have a thickness which is about 50% of the overall thickness of the bulk layer since the thicknesses of Wong encompassed a number of ratio thicknesses inclusive of 50% for the third layer and selection of the thicknesses would have been a preference selected by one of ordinary skill in the art.

8. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wong in view of Xu '923 as applied to claims 1-14, 16-18 and 22 above, and further in view of U.S. patent No. 5,288,665 (Nulman).

The difference not yet discussed is of the DC power of the first step being greater than the DC power in the second step (claim 15).

Wong's example teaches of a first power that is lower that that of the second power (col. 3, ll. 34-35 and 53-54).

According to Nulman: a target power supply during this first deposition phase is preferably set at a voltage of about -300 to about -600 volts, more preferably from about -450 to about -550 volts, and most preferably about -500 volts; and at a power level sufficient to provide a deposition rate of from about 200 to about 300 Angstroms per second. For a 6" diameter wafer, for example, such a deposition rate made be maintained using a power level of from about 9 kilowatt to about 17 kilowatts, typically

about 10 kilowatts during the first deposition phase (paragraph bridging columns 3 and 4).

A lower target power level is used in the second phase to provide a deposition rate of from about 20 to about 40 Angstroms. For example, for a 6" wafer, the power level will range from about 1 kilowatt up to about 3 kilowatts, and typically will be about 2 kilowatts, during this second phase of the deposition step (col. 4, ll. 56-63).

Nulman teaches that by using these particular power relationships for the cold and hot aluminum deposition steps, desired deposition rates can be achieved. This would enhance the control of the deposition of the aluminum layers within the contact hole.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Wong by using the power levels of Nulman to achieve desired deposition rates and enhance the control of the deposition of the aluminum layers within the contact hole.

Response to Arguments

9. Applicant's arguments with respect to claims 1-18 and 21-23 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

10. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP

§ 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gregg Cantelmo whose telephone number is (703) 305-0635. The examiner can normally be reached on Monday through Thursday from 8:00 a.m. to 5:30 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen, can be reached on (703) 308-3322.

FAX communications should be sent to the appropriate FAX number: (703) 305-3599 for After Final Responses only; (703) 305-7718 for all other responses. FAXES received after 4 p.m. will not be processed until the following business day.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

gc

September 25, 2001

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